

## DRIVETRAIN

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## BACKGROUND OF THE INVENTION

[0001] The invention relates to a drivetrain comprising a friction clutch disposed within the frictional connection between an internal combustion engine and a transmission and having an input part connected to the internal combustion engine and at least one output  
10 part connected to a transmission input shaft, as well as a disengagement device for the latter.

[0002] In a known way, friction clutches are operated via a hydraulic disengagement system comprising a manually or automatically operated master cylinder and a slave cylinder that disengages the clutch, both cylinders being connected by a hydraulic line. In so-called forced-compression clutches, the clutch is disengaged in the force-free state of the clutch, and  
15 the frictional engagement for connecting internal combustion engine and transmission is accomplished by actuation and holding of the slave cylinder under pressure via the master cylinder. In particular for dual clutches in which a common input part is branched into two output parts, each having a transmission output shaft, the connection of the clutches in this manner is advantageous. If both or one of the two disengagement devices fails, for example  
20 by loss of pressure medium, these clutches are always open and do not lock the transmission, as is the case for clutches, for example, that are normally engaged in the force-free state.

[0003] Friction clutches of the type mentioned above are usually used, in addition to manually operated transmissions, in automated transmissions, for example in automated shift transmissions (AST) or dual clutch transmissions (DCT), which are generally driven by a  
25 control device, both the clutch and the engagement and disengagement of the gears being operated automatically. If a control device of this type fails, it may happen, depending on the control strategy used, that the clutch position of one clutch or, in a dual clutch transmission, of both clutches is/ are frozen, and therefore the operation of the internal combustion engine can no longer be controlled, regardless of the transmission output speed, and thus the wheel  
30 speed is no longer controllable; that is, when the vehicle is at a standstill, for example, operation of the internal combustion engine to provide power to accessory units is no longer possible.

## OBJECTS OF THE INVENTION

[0004] The object of the present invention is therefore to propose a drivetrain that, in the event of a failure of the transmission control, enables disconnection of a clutch that no longer disengages. The implementation of this objective should be simple, cost-effective, and  
5 uncomplicated in terms of assembly. As few new parts as possible should be required. Moreover, it should be avoided that when there is a failure of the transmission control, the driver has to undertake unusual operations in order to maintain undisturbed driving performance.

## SUMMARY OF THE INVENTION

10 [0005] The objective is achieved by a drivetrain comprising a friction clutch in the power flow between an internal combustion engine and a transmission having an input part, at least one decoupling output part and at least one disengagement device, the at least one output part being decoupled from the input part in the force-free state and being brought into frictional engagement with the input part via the at least one disengagement device, the at  
15 least one disengagement device being formed of a master cylinder and a slave cylinder that is in operative connection with the master cylinder via a hydraulic line, and a pressure relief device that backs off a pressure applied between the master cylinder and slave cylinder, if operated from outside, being provided in the hydraulic line between the master cylinder and the slave cylinder.

20 [0006] Especially advantageous, according to the inventive concept, is a changeover in dual clutch, whereby for each clutch an annular part is connected in a rotationally fixed manner to the input part is operated by a disengagement device, the output part forming a frictional engagement with the input part and at least one disengagement device having available to it the aforementioned pressure relief device. Of course both disengagement  
25 devices are advantageously provided with a pressure relief device.

[0007] The operation from outside provides in this context that in the event of a defect of the control of the transmission and the automatic clutch, the driver may exert an influence on the disengagement state of the two clutches whereby he operates an actuation device to operate the pressure relief device. It can be particularly advantageous if, in the case  
30 of a dual clutch, both pressure relief devices are operable via a single actuation device. Furthermore, it may be advantageous if the driver operates this actuation device in connection with normal activities. For example, the operation of the pressure relief device may be combined with the operation of the selection lever for selecting drive modes of the vehicle,

such as selecting gears of the transmission or setting the parking brake, the operation of the pressure relief device occurring as a function of the selection lever position. For example, in the "Neutral" or "Park" selection position the pressure relief device may be operated, while, in a position for forward or reverse drive when a manual drive mode is determined in which the gears or gear ratios are shifted up or down by moving the selection lever, this does not occur.

[0008] The transmission of the signal from the actuation device to the pressure relief device can occur mechanically, for example via a Bowden cable or a linkage, hydraulically, for example via a master/slave cylinder device, or electrically (by-wire), for example via at least one switch disposed on the actuation device that is connected to a solenoid valve on the pressure relief device. Of course operative connections of this type may also be configured in combination or in another way.

[0009] In an exemplary embodiment, the pressure relief device advantageously has an input side intake from the master cylinder and an output-side discharge to the slave cylinder. Provided between them is a chamber with an ideally negligible dead volume that is expandable by means of an axially displaceable piston as a function of pressure stored in the hydraulic line. Of course the piston is sealed off from the chamber with sealing means; for example, sealing rings, such as O-rings or pistons seals as are known from master and slave cylinders, can be used. This piston is blocked in its axial displacement by a fixing device as long as the pressure relief device is not operated. In this context, the fixing device is in operative contact with the operative connection of the actuation device: for example, on the Bowden cable a pin that engages in a radical direction with respect to the piston axis may be provided that engages in the piston via movement of the Bowden cable. The piston may be fixed alternatively or additionally using other means, such as electrical means like electromagnets or piezoelectric elements.

[0010] Two pressure relief devices can advantageously be located in a housing and/or integrated in the housing of a master cylinder or slave cylinder. The integration of the pressure relief devices into a module that is comprised of an electrical actuation system, such as an electric motor or a piezoelectric element, the mechanism for conversion of the rotary movement of an electric motor into a translational movement of the master cylinder and the master cylinder can be especially advantageous, whereby the total integration of two such modules can also be advantageous for the operation of two clutches by, for example, conserving structural space and housing parts.

[0011] In another preferable embodiment, the actuation device may actuate the pressure relief device via the operative device in such a manner that it is actuated when the operative connection is de-energized; thus, according the previous manifestation, the pressure relief device enables a pressure equalization in the hydraulic line. This has the advantage, among other things, that when there is simultaneous failure of control device and actuation device, such as in a total failure of the power supply, the pressure relief device still performs its function and the clutch(es) open(s). For this purpose, an electromagnetic valve or piezoelectric element may be used that directly forms the pressure relief device in that the fluid power medium line is depressurized by movement of a sliding element or piston.

[0012] Moreover, in using an electrically powered pressure relief device, it may be advantageous to prevent the triggering of the pressure relief device when the selection lever is rapidly shifted back and forth between the "Reverse" and "Drive" drive modes, if, for example, these selection operations pass through the "Neutral" drive mode. In this case, or whenever, triggering in the "Neutral" drive mode may also be delayed. Delay times between 0.1 and 1 second have proven advantageous.

[0013] Of course the proposed volume equalization device may also be advantageous for clutches, by means of which accessory systems, such as an air conditioner compressor or an electrical machine for starting the internal combustion engine, assisted or autonomous driving of the vehicle and/or for generating electrical energy may be coupled to the drive train. In the case of a dual clutch transmission, it may be advantageous to provide an accessory system that may be decoupled from one of the two transmission input shafts and/or the crankshaft.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The invention is explained in detail in relation to Figures 1 to 4.

In the drawing:

Figure 1 shows a schematic drivetrain according to the invention; and

Figures 2 to 4 show an exemplary embodiment of a pressure relief device in various operating states.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0015] Figure 1 shows a schematically represented drivetrain 100 comprising an internal combustion engine 40 and, connected to its output side, a transmission 30 that in this case is a dual clutch 2 having two transmission input shafts 9a, 9b. In the power flow between internal combustion engine 40 and transmission 30, a dual clutch 2 having output

part 3, which is joined to the crankshaft of the internal combustion engine in a rotationally fixed manner and, conventionally, in a rigid design as a so-called flex plate - as shown in Figure 1 - may be designed as axially elastic or as a dual-mass flywheel, and being disposed with two output parts 4a, and 4b, each of which is in rotational connection with transmission input shaft 9a and 9b as so-called clutch plates having frictional linings that form frictional engagement with input part 3. For this purpose input part 3 has an axially fixedly mounted pressure plate 10c having frictional engagement surfaces disposed on both sides and is rotationally connected to ring wheel parts 10a, 10b, which are provided for each output part, are axially displaceable, are rotationally connected to input part 3, and each have a frictional engagement surface. By axial displacement of ring wheel parts 10a, 10b, the frictional engagement with the frictional surfaces of output parts 4a, 4b is produced. The annular surfaces in the force-free state are spaced from pressure plate 10c using, for example, leaf springs in such a manner that there is no frictional engagement; that is, both of the output parts are forced-compression clutches.

[0016] Clutches 2a, 2b are each engaged with an axial displacement of disengagement levers 4c and 4d. In this context, levers 4c and 4d are held in this state by the particular clutch actuation devices 5a, 5b until a disengagement of the clutch is desired. Each of the two clutches - in a known way - may be provided with a readjustment device, it being possible also for a single common readjustment device to act on both clutches. Of course according to the logic of the invention, other clutch forms and configurations, such as forced-tension clutches, may also be advantageous.

[0017] The two friction clutches 2a and 2b are operated by disengagement devices 5a, 5b, each of which comprises master cylinder 6a, 6b, each of which preferably is actuated in a known way via an electric actuator 21a, 21b, a slave cylinder 8a, 8b, which preferably may be ring cylinders disposed concentrically around transmission input shafts 9a, 9b, cylinders distributed around the perimeter surrounding the transmission input shafts or cylinders disposed around a linkage essentially parallel to the transmission input shafts, and a line 7a, 7b connecting slave cylinders 8a, 8b and master cylinders 6a, 6b.

[0018] Integrated in line 7a, 7b is pressure relief device 1, which contains within a housing pressure relief devices 1a, 1b for the particular disengagement devices 5a, 5b. Of course the two pressure relief devices 1a, 1b may also be configured separately and may be integrated, for example, in one of the components of the disengagement system, for example in master cylinder 6a, 6b or slave cylinder 8a, 8b. Pressure relief device 1 is controlled from

outside by, for example, the driver. For this purpose, the driver has at his disposal an actuation device **11**, which in the illustrated exemplary embodiment is the selection lever for selecting drive modes of the vehicle having the functions, for example: Park P, Reverse R, Neutral N, Drive D and manual jog control +,-.

5   **[0019]**       The desired operation is transmitted from the actuation device **11** to pressure relief device **1** via an operative connection **12**, which may be a Bowden cable or an electrical connecting means, an operative connection in the shown example acting on two fixing devices **18** that prevent a volume equalization and in the case of an actuation enable it.

10   **[0020]**       The mode of operation of drivetrain **100**, which is depicted in Figure 1, proceeds as indicated below.

15   **[0021]**       Transmission control device **50** controls the transmission actuation device, which disengages and engages gears in the transmission according to the driving situation. For this purpose the control device coordinates the actuators, such as electric motors, **21a**, **21b**, for actuation of clutches **2a**, **2b**, whereupon drivetrain **100** can be made completely  
20   automatic. Alternatively, the driver, by tapping on the selection lever in the position +,- can shift in a power-assisted way using automatic clutch **2**. If master cylinders **6a**, **6b** are in their idle position, that is, clutches **2a**, **2b** disengage, the pressure in the disengagement devices **5a**, **5b** is brought up to atmospheric pressure via connections to a compensating tank (not shown). Any pressurization that may be present is reduced. When master cylinders **6a**, **6b** are  
25   operated, the connection to the compensating tank is closed, in line **7a**, **7b** a pressure is reduced and friction clutches **2a**, **2b** are actuated. If control device **50** fails in a situation of this type, master cylinders **6a**, **6b** remain in their transitory position, whereupon clutches **2a**, **2b** remain in frictional engagement according to the position of the lever mechanism **4c**, **4d**. In order to then produce a decoupling of internal combustion engine **40** transmission **30**,  
30   actuation device **11** is activated and thus the pressure relief device actuates so that the pressure built up in lines **7a**, **7b** is reduced and clutches **2a**, **2b** are opened. In an especially advantageous manner, various positions of actuation device **11** are used as selection levers to operate the pressure relief device. For example, pressure relief device **1** is always operated in the positions Neutral N and Park P, so the driver is not confronted with the decision to have to operate the actuation device in certain situations. Rather instead volume equalization device **1** is conjointly operated in situations in which the driver would operate the selection lever anyway, for example, when stopping or in unsafe driving situations.

[0022] Figure 2 shows detail of a pressure relief device **1a** for a disengagement device **5a** of Figure 1 with reference to an exemplary embodiment. Housing **22** has one connection **13** from the master cylinder side and one connection **14** to the slave cylinder side and is installed in hydraulic line **7a**. Between the two connections **13**, **14**, a chamber **15** is formed with a specified, ideally minimized dead volume that is limited by a piston **16**. Piston **16** is located in another chamber **26** and seals off the two chambers **15**, **26** from each other via a sealing means **20**, which can be a ring seal like a piston seal or an O-ring. The fixing device **18**, which in the shown exemplary embodiment is configured as a pin and is a continuation of Bowden cable **12** that is guided through duct **19**, holds piston **16** at its axial position while in a latched state. Duct **19** in this context can have a sealing effect and, moreover, accommodates a sheathing of Bowden cable **12**. For the minimization of the dead volume of chamber **15**, piston **16** is impinged by a force that is applied by energy storage device **17**- represented here as a coil spring. An opening **27** is provided in housing **22** for pressure equalization. Of course the impingement of the piston with a force for minimizing the dead volume of chamber **15** can also be provided using additional or alternative means; for example, opening **27** may be closed or pressurized, whereby energy storage device **17** is dimensioned accordingly or can be eliminated. In a special exemplary embodiment, the opening **27** can be impinged with a pressure that is provided by an actuation device **11** (Figure 1), for example, via a hydraulic switch with a pressure supply device.

[0023] Figure 2 shows pressure relief device **1a** in a fixed state. Figure 3 shows the same pressure relief device **1a** in an actuated state with a pulled back Bowden cable **12** and thus a released fixing device **18**, which was pulled out of a recess **28** in piston **16** so that, when there is pressure in line **7a** due to a compressive force acting on piston **16** that is greater than the spring force of energy storage device **17**, piston **16** is displaced and chamber **15** thus receives an increase in volume that causes clutch **2a** (Figure 1) to be disengaged.

[0024] Figure 4 shows a situation in which line **7a** is depressurized, for example when a master cylinder **6a** is in an idle position and is connected to the compensating tank. In this case, the fixing device is also triggered by actuation device **11** (Figure 1) via Bowden cable **12**, because, for example, the driver, when control device **50** is operational, has selected the position Park or Neutral. However, nothing changes regarding the position of piston **16** because it is held in its position by energy storage device **17**. As a result the volume of chamber **15** remains constant. It should be pointed out that when energy storage device **17** is appropriately designed, especially with the mass of piston **16** and/or the hysteresis of sealing

means 20, pressure relief device 1a can simultaneously be used as a so-called "Kribbel" filter (integrated vibration damper) for damping vibrations in line 7a that stem from axial vibrations of the internal combustion engine and are transmitted via the clutch.

[0025] The patent claims submitted along with the application are formulation proposals without prejudice for the attainment of ongoing patent protection. The applicant reserves the right to claim additional feature combinations that so far are only disclosed in the description and/or drawings.

[0026] References used in the dependent claims point to the further formation of the subject matter of the main claim by the features of each dependent claim; they are not to be understood as renunciation of the attainment of a separate, concrete protection for the feature combinations of the referred dependent claims.

[0027] Because the subject matter of the dependent claims may form separate and independent inventions with respect to the state of the art on the priority date, the applicant reserves the right to make them the subject matter of independent claims or separation statements. They may furthermore also include independent inventions that have a configuration independent of the subject matters of prior dependent claims.

[0028] The exemplary embodiments are not to be understood as a limitation of the invention. Rather, numerous amendments and modifications are possible within the context of the present publication, especially such variants, elements and combinations and/or materials as may be inferred by one skilled in the art with regard to the resolution of the problem using, for example, a combination or modification of individual features or elements or methodological steps that are described in connection with the general description and embodiments as well as the claims and that are contained in the drawings and, using combinable features, lead to a new subject matter or to new methodological steps or methodological sequences, even if they pertain to manufacturing, testing and operating method.